WHAT IS CLAIMED IS:

1. A mercury adsorbent composition comprising

a natural diatomite in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm, said diatoms having the surfaces thereof treated with an activating material capable of removing mercury by chemical bonding forming surface treated diatoms which when brought into contact with a mercury containing fluid react with mercury to cause mercury to separate from the fluid by chemical bonding to the surface treated diatoms.

2. The composition of claim 1 wherein the size of the siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures are selected to have a majority of diatoms having a size in the range of about 10 μm to about 150 μm.

3. The composition of claim 1 wherein the natural diatomite has a particle size distribution from about 5 μm (d_{10}) to about 82 μm (d_{90}).

4. The composition of claim 1 wherein the mercury species defining the mercury in the fluid is an organic mercury species.

5. The composition of claim 1 wherein the treating activating material capable of removing mercury by chemical bonding applied to the surfaces of the diatoms forming the surface treated diatoms is selected to have a high mercury loading capacity.

6. The composition of claim 1 wherein the treating activating material capable of removing mercury by chemical bonding to the surfaces of the diatoms forming the surface treated diatoms is selected to have a fast mercury removal rate.

7. A composition for separating mercury from a mercury containing fluid comprising

a substrate including natural diatomite, said natural diatomite being in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm; and

a treating activating material capable of removing mercury by chemical bonding applied to the surfaces of the diatoms forming a substrate having surface treated diatoms, said surface treated diatoms when brought into contact with a mercury containing fluid being configured to react with mercury to cause

mercury to separate from the fluid by chemical bonding to surface treated diatoms.

8. The composition of claim 7 wherein the size of the siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures are selected to have a majority of diatoms having a size in the range of about 10 μm to about 150 μm.

9. The composition of claim 7 wherein the natural diatomite has a particle size distribution from about 5μm(d_{10}) to about 82 μm(d_{90}).

10. The composition of claim 7 wherein the treating activating material capable of removing mercury by chemical bonding to the surfaces of the diatoms forming a substrate having surface treated diatoms is selected to have a high mercury loading capacity.

11. The composition of claim 10 wherein the treating activating material has high mercury loading capacity of at least 300 mg Hg/g.

12. The composition of claim 10 wherein the treating activating material has high mercury loading capacity greater than 400 mg Hg/g.

13. The composition of claim 10 wherein the treating activating material has a high mercury loading capacity greater than 425 mg Hg/g.

14. The composition of claim 7 wherein the treating activating material capable of removing mercury by chemical bonding to the surfaces of the diatoms forming a substrate forming surface treated diatoms is selected to have a fast mercury removal loading rate.

15. The composition of claim 14 wherein the fast mercury removal is greater than about 99.8% mercury removal in 30 minutes from a starting ionic mercury concentration of about 9700 ppb at 1 g/L product loading in an aqueous solution.

16. The composition of claim 14 wherein the fast mercury removal is greater than about 99.9% mercury removal in 30 minutes from a starting ionic mercury concentration of about 9700 ppb at 1 g/L product loading in an aqueous solution.

17. The composition of claim 14 wherein the fast mercury removal is greater than about 99.0% mercury removal in 240 minutes from a starting ionic mercury concentration of about 7800 ppb at 100 g/L product loading in an oil solution.

18. The composition of claim 7 wherein the treating activating material is selected to be a gamma-

mercaptopropyltrimethoxysilane as a mercury adsorbing functional group.

19. The composition of claim 7 wherein a solvent for the treating activating material is selected to be a non-alcohol solvent.

20. The composition of claim 19 wherein the non-alcohol solvent is chloroform.

21. A mercury adsorbent product for separating mercury from a mercury containing fluid comprising

a substrate including natural diatomite, said natural diatomite being in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm; and

a treating activating material capable of removing mercury by chemical bonding to the surfaces of the diatoms forming a substrate having surface treated diatoms, said surface treated diatoms when brought into contact with a mercury containing fluid being configured to react with mercury to cause mercury species defining the mercury to separate from the fluid by chemical bonding to surface treated diatoms, said surface treated diatoms being selected to have a measured ionic mercury

loading capacity higher than about 200 mg Hg/g product in aqueous solution and a mercury removal greater than about 98.0% in an aqueous solution with a starting ionic mercury concentration of about 9700 ppb at 1 g/L product loading after about a 30 minutes treatment.

22. The mercury adsorbent product of claim 21 wherein said surface treated diatoms are selected to have a measured ionic mercury loading capacity higher than about 300 mg Hg/g product in aqueous solution.

23. The mercury adsorbent product of claim 21 wherein said surface treated diatoms are selected to have a measured ionic mercury loading capacity higher than about 400 mg Hg/g product in aqueous solution.

24. The mercury adsorbent product of claim 21 wherein said surface treated diatoms are selected to have a calculated theoretical maximum ionic mercury loading capacity higher than about 600 mg Hg/g product in aqueous solution.

25. The mercury adsorbent product of claim 21 wherein said surface treated diatoms are selected to have a mercury removal greater than about 98.7% in an oil solution with a starting ionic mercury concentration of about 7800 ppb at 10 g/L product loading after about a 240 minute treatment.

26. The mercury adsorbent product of claim 21 wherein said surface treated diatoms are selected to have a mercury removal greater than about 98.1% in an aqueous solution with a starting ionic mercury concentration of about 90 ppb at 1 g/L product loading after about a 30 minute treatment.

27. The mercury adsorbent product of claim 21 wherein said surface treated diatoms are selected to have a mercury removal greater than about 89.2% in an aqueous and oil solution with a starting elemental mercury concentration of about 566 ppb at 10g/L product loading after about a 240 minute treatment.

28. The mercury adsorbent product of claim 21 wherein said surface treated diatoms are selected to have a mercury removal greater than about 89.7% in an aqueous solution with a starting organic mercury ($C_9H_9HgNaO_2S$) concentration of about 566 ppb at 10 g/L product loading after about a 240 minute treatment.

29. The mercury adsorbent product of claim 21 wherein said surface treated diatoms perform mercury removal in an acidic condition with a pH as low as about 0.

30. The mercury adsorbent product of claim 21 wherein said surface treated diatoms perform mercury removal in an basic condition with a pH as high as about 11.2.

31. The mercury adsorbent product of claim 21 wherein said surface treated diatoms maintain stability after about 30 days in an oxygen atmosphere.

32. The mercury adsorbent product of claim 21 wherein said surface treated diatoms perform mercury removal after heat treatment at temperatures in the range of about 100°C to about 200°C.

33. The mercury adsorbent product of claim 32 wherein said surface treated diatoms perform mercury removal after heat treatment at temperatures in the range of about 200°C.

34. A heavy metal adsorbent product for separating gold from a gold containing fluid comprising

a natural diatomite being in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm; and

a treating activating material capable of removing gold by chemical bonding applied to the surfaces of the diatoms forming a substrate having surface treated diatoms, said surface treated diatoms when brought into contact with a gold containing fluid being configured to react with gold to cause gold to separate from the fluid by chemical bonding to surface treated diatoms,

said surface treated diatoms being selected to have a gold removal greater than about 89.9% in an aqueous solution with a starting ionic gold concentration of about 460 ppb at 1 g/L product loading after about a 30 minutes treatment.

35. A method of separating mercury from fluids comprises the steps of:

contacting and passing a fluid containing mercury through a natural diatomite in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm wherein said diatoms have the surfaces thereof treated with an activating material capable of removing mercury by chemical bonding forming surface treated diatoms which upon contact with a mercury containing fluid react with mercury to cause mercury to separate from the fluid by chemical bonding to the surface treated diatoms.

36. The method of claim 35 further comprising the step of converting elemental mercury to ionic mercury prior to the step of contacting and passing.

37. The method of claim 36 further comprising the step of converting covalently bonded mercury to ionic mercury prior to the step of contacting and passing.

38. The method of claim 37 wherein the step of contacting and passing further includes a treating activating material selected to be a gamma-mercaptopropyltrimethoxysilane as a mercury adsorbing functional group.

39. The method of claim 38 wherein the step of contacting and passing further includes a solvent for the treating activating material is selected to be a non-alcohol solvent.

40. The method of claim 39 wherein the step of contacting and passing further includes a solvent for the treating activating material wherein the non-alcohol solvent is chloroform.

41. The method of claim 40 wherein the step of contacting and passing includes the natural diatomite wherein the size of the siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures are selected to have a majority of diatoms having a size in the range of about 10μm to about 150 μm.

42. The method of claim 41 wherein the step of contacting and passing includes the natural diatomite having a particle size distribution from about 5 μm (d_{10}) to about 82 μm (d_{90}).

43. The method of claim 42 wherein the step of contacting and passing includes the natural diatomite being in the form of a porous substrate.

44. A process for manufacturing a mercury adsorbent composition comprising the steps of

forming a substrate of a natural diatomite in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm;

treating the surfaces of the diatoms with an activating material capable of removing mercury by chemical bonding forming surface treated diatoms which when brought into contact with a mercury containing fluid react with mercury to cause mercury species defining the mercury to separate from the fluid by chemical bonding to the surface treated diatoms.

45. The process of claim 44 wherein the step of treating includes

mixing the natural diatomite with a treating activating material comprising gamma-mercaptopropyltrimethoxysilane.

46. The process of claim 44 wherein the step of treating includes

mixing the natural diatomite with a treating activating material comprising gamma-mercaptopropyltrimethoxysilane in a non-alcohol solvent.

47. The process of claim 46 wherein the step of treating includes

mixing the natural diatomite with a treating activating material comprising gamma-mercaptopropyltrimethoxysilane in a non-alcohol solvent of chloroform.

48. The process of claim 44 wherein the step of treating uses a natural diatomite containing silanol and further comprising the step of

hydrating the natural diatomite containing silanol to increase surface silanol groups.

49. The process of claim 44 further comprising the step of

forming the natural diatomite comprising surface treated diatoms into pellets.

50. A waste removing material comprising

a natural diatomite in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm, said diatoms having the surfaces

thereof treated with an activating material capable of removing mercury by chemical bonding forming surface treated diatoms which when brought into contact with a mercury containing aqueous solution having at least one species of elemental, ionic and organic mercury react with mercury to cause mercury defining the mercury to separate from the fluid by chemical bonding to the surface treated diatoms.

51. A waste removing material comprising

a natural diatomite in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm, said diatoms having the surfaces thereof treated with an activating material capable of removing mercury by chemical bonding forming surface treated diatoms which when brought into contact with a mercury containing oils having at least one species of elemental, ionic and organic mercury react with mercury to cause mercury species defining the mercury to separate from oil by chemical bonding to the surface treated diatoms.

52. A mercury concentration monitoring material comprising

a natural diatomite in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings

defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm, said diatoms having the surfaces thereof treated with an activating material capable of removing and concentrating mercury by chemical bonding forming surface treated diatoms which when brought into contact with one of a mercury containing aqueous solution having at least one species of elemental, ionic and organic mercury and a mercury containing oils having at least one species of elemental, ionic and organic mercury react with mercury to cause mercury species defining the mercury to separate therefrom by chemical bonding to the surface treated diatoms.

53. A mercury removal material for use as a filter aid in a continuous filtration process comprising

a natural diatomite in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm, said diatoms having the surfaces thereof treated with an activating material forming surface treated diatoms and defining a filter aid for us in a continuous filtration process for removing mercury by chemical bonding which when brought into contact with and filtering one species of a mercury containing aqueous solution having at least one

species of elemental, ionic and organic mercury and a mercury containing oils having at least one of elemental, ionic and organic mercury enables the surface treated diatoms to react with mercury to cause mercury species defining the mercury to separate therefrom by chemical bonding to the surface activated diatoms.

54. A mercury removal pellet material comprising

a natural diatomite in the form of siliceous frustules of diatoms having a surface punctuated by a series of openings defining frustule structures having sizes in the range of about 0.75 μm to about 1,000 μm, said diatoms having the surfaces thereof treated with an activating material forming surface treated diatoms and defining a mercury removal pellet material which when configured in a column structure for removing mercury by chemical bonding which when brought into contact with and having passed through a column structure formed of mercury removal pellet material one of a mercury containing aqueous solution having at least one species of elemental, ionic and organic mercury and a mercury containing oils having at least one species of elemental, ionic and organic mercury enables the surface treated diatoms to react with mercury to cause mercury

species defining the mercury to separate therefrom by chemical bonding to the surface treated diatoms.

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